THE STRUCTURE AND THE ENVELOPE OF A PREFABRICATED PANEL BUILDING AND THE METHOD OF ASSEMBLY

This invention refers to the structure of a building and its building envelope made with compressed agricultural cellular fiber prefabricated panels and the method of assembly.

Known technologies advance composite panel walls with metal structures, fiber glass, mineral fiber or polyurethane resins insulation, and composite walls structure with reinforced concrete, fiber glass, mineral fiber or polystyrene insulation for industrial construction and housing.

Drawbacks for such solutions are the large consumption of these materials, all with different properties and the high cost of job site labor. Other drawbacks are the large amount of excavation and the foundations needed due to high load ratio per area unit, as well as low levels of thermal insulation, waterproofing and sound absorption of these building envelope elements.

Other known technology advances a light structure (RO 11 49 89 B1) from typical sandwich panels built as a "U" profile metal frame with an asbestos outer layer, polystyrene or other insulator and a wood particle board, glued together in the "U" shaped, welded, steel members structure.

Drawbacks for this solution are the high toxic content of all materials involved including binder in either, stable condition or due to burning, and the lack of thermal break and fire protection for the metal frame.

Another known technology (US Patent 5,024,033) advances prefabricated construction panels with vertical and horizontal structural members between boards of rigid insulating material and top and bottom sealing runners.

These panels have the disadvantage that that they use structural members without fire protection and thermal break, with high job site labor content and high material consumption as well as a large number of operations and finishing materials after panel assembly.

Another technology advances prefabricated panel construction (US Patent 5,608,999) based on PVC profiles or extruded thermoplastic shapes used as concrete forms. Profiles engage each other through a interlocking mechanism which allows for double panel formation as a continuous chamber for concrete casting.

This technology has several drawbacks from the point of view of concrete reinforcing and finishing, as well as thermo insulating, waterproofing and sound absorption properties for exterior or interior walls and foundation elevations.

The invention presented herein resolves the problem of building structures and building envelopes' efficient prefabrication, reducing job site labor to a minimum, and unifying any given building envelope and structure into a homogeneous construction system based on prefabricated structural steel elements sandwiched between compressed, prefabricated cellular fiber panels, where the only variance occurs at the structural elements level, function to their position in the building, - as foundations, floors, exterior or interior walls, and roofs.

This invention solves also the problem of successfully replacing all rigid connections of a given building structure with flexible joints, whereby gradually increasing specific connector's sizes and tolerances, substantial resistance to earthquake impact is allowed.

Additionally, this invention has the advantage that buildings erected with compressed, prefabricated cellular fiber panels in the configuration shown, are much lighter than similar buildings erected with concrete, brick, stone or other traditional materials, are environmentally friendly due to wheat straw fiber used as raw material and much easier to erect, - 4 low skilled workers with hand tools can build a 100 square meters housing structure in one day.

At the same time, it eliminates most other construction materials drawbacks such as thermal and acoustical conductivity, water absorption, porosity, friability, mass or weight, fragility, inconsistence, high labor volume for finishes, low fire, chemical agents, insects and bacterial resistance, low nail and screw retention, and low job site handling.

A detailed description of this invention follows the Figures No. 1 to 34's explanation below.

Fig. 1. Isometric perspective of a partial concrete form panel assembly for typical and corner position with the anchoring method

Fig. 2. Expanded isometric perspective of a typical assembly joint for concrete form panels and concrete reinforcing detail

Fig. 3. Expanded isometric perspective of a PVC spacer at joint, expanded concrete reinforcing detail and the vertical anchoring adjustment mechanism

Fig. 4. Isometric perspective of a partial interior wall panel with top and bottom connection

Fig. 5. Expanded isometric perspective of a PVC spacer at corner, expanded concrete reinforcing detail and the vertical anchoring adjustment mechanism

Fig. 6. Isometric perspective of a partial exterior wall panel assembly for typical and corner joint, with the method of assembly at perimeter plates connection with the foundation elevation, typical floor beam plate and the typical open web floor truss

Fig. 7. Isometric perspective of a partial exterior wall typical panel with its structural elements and the method of assembly

Fig. 8. Isometric perspective of a partial vertical structural element (16) at exterior wall panels joint area, its structural shoulder support (19) and the method of assembly

Fig. 9. Isometric perspective of a partial central vertical structural element (17) from a typical exterior wall panel, its structural shoulder supports (19) and the method of assembly

Fig.10. Isometric perspective of a partial vertical structural element, variance (16'), from a typical exterior wall panel joint area, its structural shoulder supports (19) and the method of assembly

Fig.11. Isometric perspective of a partial vertical structural element (18) from an exterior panel corner joint area, its structural shoulder supports (19) and the method of assembly

Fig.12. Plan section of a typical exterior wall panel at corner joint area, with the vertical structural element (18), the wood spacers (24) and the method of assembly

Fig.13. Isometric perspective of a partial beam plate (22) over the foundation elevation at corner and the method of assembly

Fig.14. Isometric perspective of a partial beam plate (23) over typical exterior wall at corner and the method of assembly

Fig.15. Plan section of a typical, exterior wall panels joint, with the 2 adjoining vertical structural elements (16), the wood spacers (24) and the method of assembly

Fig.16. Plan section of a typical exterior wall panels joint, with the vertical structural element, variance (16'), the wood spacers (24) and the method of assembly

Fig.17. Plan section of a typical interior wall panel connection with an exterior or an interior wall panel, the metal connection profiles (55) and the method of assembly

Fig.18. Plan section of a typical, side by side interior wall panel connection with another interior wall panel, the metal connection profiles (55) and the method of assembly

Fig.19. Cross sectional view of a typical interior wall panel connection at the top with the bottom flange of the open web truss (21) from the floor above, the metal connection profile (28) and the method of assembly

Fig.20. Cross sectional view of a typical interior wall panel connection at the bottom with the floor panel (26), the metal connection profile (27) and the method of assembly

Fig.21. Isometric perspective of a partial floor structure with the open web trusses (21), the structural metal shoulder supports (20), the metal lateral braces (54), the floor panels (26), the ceiling panels (29) and the method of assembly

Fig.22. Cross sectional view of a typical exterior wall panel connection with the foundation elevation (10) through the steel plate (22) over the foundation, with the vertical structural element (17), the structural metal shoulder support (20), the open web truss (21) and the method of assembly

Fig.23. Isometric perspective of a partial exterior wall cladding panels (1) connection, the aluminum spacers (48), the aluminum mounting plates (47), the thermal break (49) and the method of assembly

Fig.24. Plan section of a punch press operation die pattern for the metal web (31) of an open web truss (21) with its reinforcing grooves (34) and the folding lines (57)

Fig.25. Isometric perspective of a partial open web truss (21), with its slanted metal web (31), the vertical mullion (30), the horizontal metal runners (32), the wood core elements (33) and the method of assembly

Fig.26. Plan section of a partial exterior wall cladding panels (1) connection, the aluminum spacers (48), the exterior wall panel (50) and the method of assembly

Fig.27. Cross sectional view of an exterior wall panel connection with the roofing structure and its enclosures, the steel beam plate (23), the open web truss (21) as a structural rafter and floor truss, the steel mounting plate (46), the exterior roofing panel (1) and the method of assembly

Fig.28. Cross sectional view of a typical exterior wall panels vertical connection at floor with open web truss (21), the metal shoulder support (20), the steel beam plate (23), the vertical steel structural element (17), the structural shoulder supports (19), the wood spacer (24) and the method of assembly

Fig.29. Cross sectional view of an exterior wall panels connection with a window frame at sill with the continuous wood connector (59), the wood spacer (24), the horizontal aluminum window frame member (60) and the method of assembly

Fig.30. Isometric perspective of a steel plate top connector for concrete form panels (1)

Fig.31. Isometric perspective of a steel plate bottom connector for concrete form panel (1)

Fig.32. Isometric perspective of a typical concrete form panel anchoring plate (6) with the leveling mechanism (81), the telescoping anchoring bars (80), the anchors (8), the method of adjustment and the method of assembly

Fig.33. Isometric perspective of typical field PVC spacer for concrete form panels equal spacing and reinforcing during concrete pouring and the method of assembly

Fig.34. Isometric perspective of a partial building with its structure and the building envelope made with Prefabricated, Compressed Cellular Fiber Panels

Note:
Regarding the above Figures and their graphic presentation it should be mentioned that several continuous or dotted lines as well as repetitive and nonessential graphic elements have been deleted for clarity reasons and concept simplification.

In accordance with this Invention the Structure and the Envelope of a building can be made from prefabricated, compressed cellular fiber panels as shown in Fig. 1, Fig. 4, fig. 6, Fig. 27, Fig. 34 and the description below, as a continuous interface between the foundation, walls, floors and roof structures and other components, all "sandwiched" between the panels in order to create an integral, unitary building with very high performance standards.

At a building foundation level, it has been assumed a concrete slab on grade with perimeter rebar dowels for the foundation elevation, where steel plate connectors (66), Fig.31, are imbedded with down prongs (67) into concrete at equal distances on the outside and the inside of dowels alignment, after upward prongs (65) adjustment in slots (64). Panels (1) are positioned side by side, Fig.1, to match prongs (65) with PVC spacer (3) in between, Fig.2.

At the top of the first 2 panels (1) the steel plate connector (5), Fig.1 and Fig.2 is attached as shown in order to reinforce the outside joint of the concrete form panels, the same sequence to be repeated along the outer concrete form panels alignment, Fig.1. After tying vertical rebars (15), Fig.2, to the bottom dowels, horizontal rebars (4) are introduced through the vertical openings of PVC spacers (2) and (3) and tied to them using holes (14) and to the vertical rebars (15), Fig.2, Fig.3 and Fig.5.

At this time the PVC field spacers (9) are introduced into the outer layer of panels (1) predrilled holes, Fig.1 and Fig.33, fastening flanges 74 by screwing the treaded core (77) to the main spacer's body 75, with the second, inner flange 74 to be fastened when the inner panels (1) are in place.

Following the installation of inner layer concrete form panels (1) by anchoring steel plate connectors (66) into concrete, placing the two adjacent panels (1) on to the steel plate (66) with the other end of PVC spacer (3) in between and the top steel plate (5) anchoring the panels top side, the second flanges (74) of the field PVC spacers (9) are fastened to the spacer's body (75) and steel anchors (8) of the adjustment steel plates (6) are anchored to the concrete slab, Fig.1 and Fig.32.

The adjustment steel plates (6) are fastened to the steel anchors (8) through treaded steel bars (80) and sliders (7) are attached to guiding PVC projection (11), which was initially reinforced with steel bar (12), Fig 1 and Fig.3. Telescoping galvanized steel bars (13) and (81) are now fastened to slider (7) and to adjustment plate (6), in order to allow the reinforcing and the proper vertical alignment of the concrete form panels.

Subject to concrete being poured in the newly created concrete form, vibrated and leveled at the top, Fig.1, the bituminous elastomeric membrane (25), Fig.6 and Fig.22 is installed in contact

with the top of the concrete elevation (10) as a thermal break and an anti oxidant for the steel plate (22) which is now fastened to the concrete with steel anchors (45), Fig.13 and Fig.22.

A typical exterior wall panel, Fig.7, is entirely shop fabricated including elements (1), (16), (17), (19) and (24) or partially job site finished if variance (16'), Fig.10 is used instead of (16) according to a specific project requirements. Its constant width of 1200mm dictates the vertical and horizontal structural members (19), (16) or (16') and (21) configuration as articulated steel frames with constant 600mm spacing from each other. Its sandwich structure has generated by extrapolation the floor, the roof, the interior wall and the concrete form structures and functions which interface with each other in order to create an unitary building.

The construction of this panel, Fig.7, starts with structural steel supports (19) being fastened with bolts (36) to structural members (16) and (17), Fig.8, Fig.9 and Fig.10 or Fig 11 for corner panels, and wood spacers (24) to members (16) with self tapping screws (39), Fig.15.

The panels (1) and the structural members (16), (17) have predrilled, corresponding holes for attachment to each other with self tapping screws, as in Fig.7. Prior to storage, a number of 5, equally spaced holes are drilled on to structural members (16) long leg for future assembly with connection bolts (41), Fig.15.

The site erection of the exterior panels starts from the corner by adjusting the steel plate's (22) sides to receive the double panel, Fig.6, miter welding of the two adjoining steel plates, Fig.13, installation of the first adjoining corner panel in square and plumb position with temporary bracing, steel plate's (22) fastening to the vertical members (16) and (17) using access holes (70) and self tapping screws (37), Fig.14, as well as structural support shoulders (20) fastening, Fig.6 and Fig.22.

The erection of the second corner panel, Fig.6, which incorporates the structural vertical corner member (18) with its structural shoulder supports (19), Fig.11 and wood spacers (24), Fig.12, follows the same procedure as the first corner panel, - previous paragraph.

The erection and the connection of two typical exterior wall double panels follows the steps shown in Fig.15 for typical loads and Fig.16 for larger specified loads. The structural vertical members (16) longer legs, Fig.15, embrace the shorter legs from the adjacent panel's member and the connection is made through predrilled holes and self tapping screws (41). For Fig.16, when the panels are in position, the structural vertical member (16') attached to one panel is introduced into the next panel and fastened to it through wood spacers (24) and screws (38).

For floors, after anchoring the open web trusses (21) at both ends, on to structural shoulder supports (20) with mechanical assembly bolts (42), Fig.6, Fig.21, Fig.22, lateral bracing strips (54) are cross mounted as shown; Fig.21 together with panels (1) as floor panels (26) and ceiling panels (29).

The open web truss (21), Fig.25, is the result of assembling the vertical structural elements (30), the structural elements at 45 degrees (31), the horizontal structural elements (32) and wood strips

(33), with pop rivets (44), after a punch press process for all metal parts, whereby folding lines (57) are followed and reinforcing grooves (34) are created.

The perimeter steel plate beam (23) as a perimeter structural beam for a typical floor Fig.6, Fig.14 and Fig.28 is installed starting from the corner, by mounting the lower half with the side flanges covering the top of the exterior wall panels, the cut outs (68) and slotted holes (71) in line with the 2" space between panels (1) and the structural shoulder support holes (19), by miter welding the other lower half at 90 degrees with the first half and repeating in reverse the same operations for the upper half (23), Fig.6 and Fig.14. At this stage, following the connection of the entire beam (23) to the structural shoulder supports (19) through holes (71), the lower half side flanges are fastened to the vertical structural elements (17), (16), (16'), (18) and wood spacers (24) through self tapping screws (37) and slotted holes (70), Fig.6, and Fig.14, similar to exterior wall panels fastening to structural perimeter beam (22).

The exterior wall panels in connection with PVC or metal window openings, Fig.29 have structural vertical members (16), (16'), (17), (18) and wood spacers (24), recessed from the window frame alignment in order to allow the continuous wood support (59) installation in connection with the window frame. For regular window sizes, the structural beam plate (23) fulfils the lintel function; for larger sizes, subject to imposed loads and design requirements, a different structural design can be implemented.

The interior wall assembly and erection is shown in Fig.4, Fig.17, Fig.18, Fig.19, and Fig.20. The wall panel (1) as an interior wall panel is fastened at the bottom as in Fig.20 using "U" shaped galvanized steel profiles (27) anchored to floor panels (26) and a similar "U" shaped profile (28) anchored with screws (39) to the wood strip (33) from the bottom chord of the structural floor truss (21), Fig.4 and Fig.19.

For the vertical joint connection of two adjacent panels, the steel shapes (55) are used as in Fig.18, following the tongue and groove principle, and similarly for interior wall to exterior wall connection as in Fig.17.

The roofing structure and enclosure's configuration is close to that of a typical floor, the difference being that for the fastening of the structural open web truss' (21) top chord, which now can be slanted, instead of the structural shoulder support (20), Fig.27, Fig.28, a structural knee support (46), Fig.27 will be used. It will be installed following the structural shoulder support (19) holes alignment in order to maintain the rafters spacing in line with the vertical structural elements (16), (16'), (17) and (18).

For an increased thermal insulation, sound absorption, waterproofing and fire rating function of the exterior wall panels, during erection of each floor, a cladding with panels (1) as in Fig.23 and Fig.26 will be added by overlapping exterior panels joints with a full size panel. Consequently, profiles (48) as structural support and spacers for the added panels, will be installed between exterior double panels joints (50), Fig.26, panels (1) being installed on to profiles (48) using steel mounting plates (47).